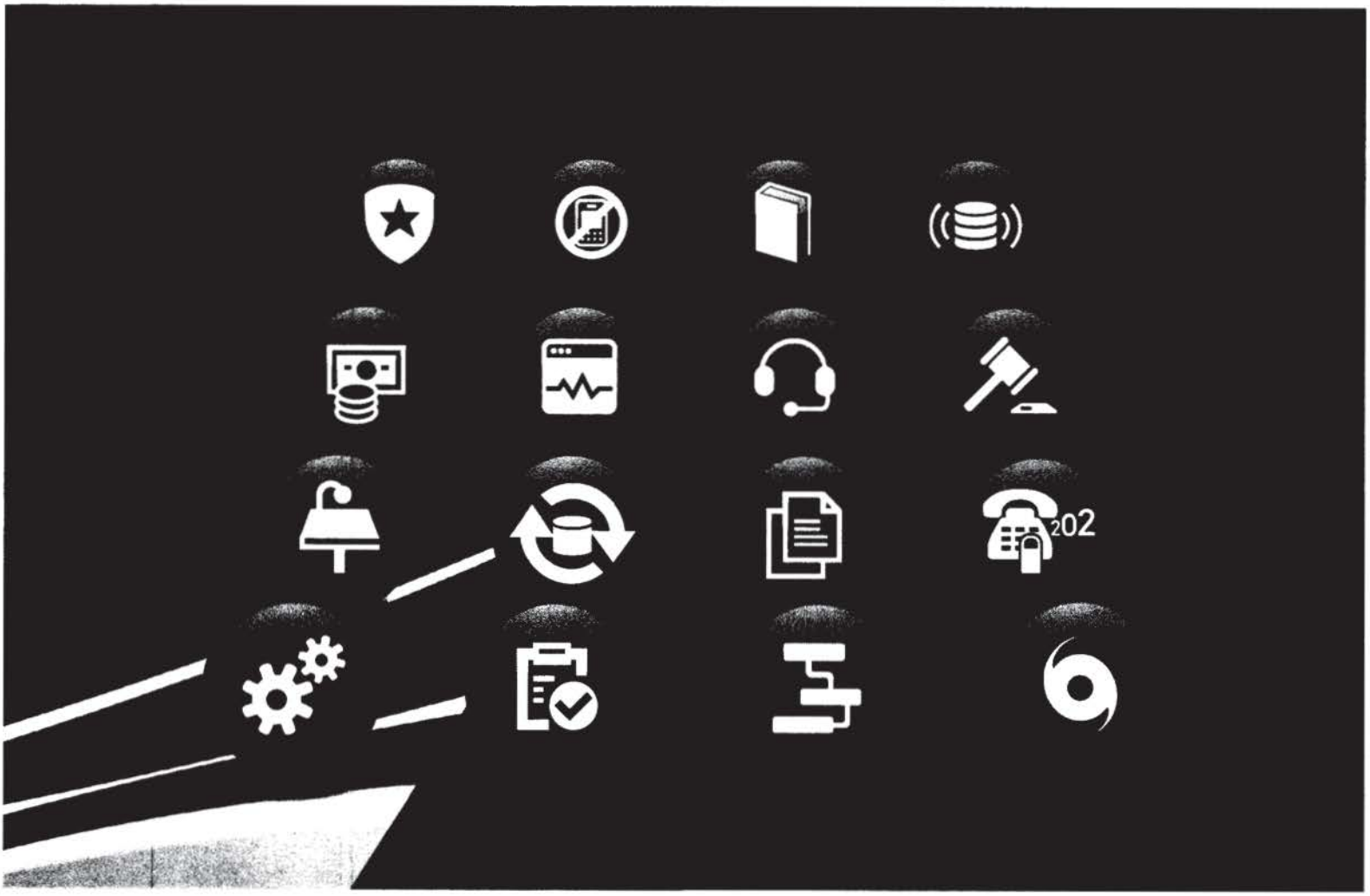
Equipment Identifier Registry (EIR) Solution



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Introduction and Market Overview

Recent studies show that by 2016, mobile phone shipments inclusive of smart phones will reach a total of 2.23 billion units worldwide. While computing power of mobile phones continues to improve, and the usage model shifts to hungry data applications, so will the probability of one's device being stolen as smart phones remain the predominant choice of consumers with newer and flashier models hitting the market every several months.

The New York Times reported that in 2011-2012, roughly one out of three robberies nationwide have involved the theft of a cell phone. The thefts have grown most rapidly in urban areas; cell phones are stolen in more than 40 percent of all robberies in New York City and 38 percent of robberies in the District of Columbia, according to the FCC and local law enforcement agencies[1].

Our findings outline the following (see Theft and Loss Model in North America in Figure 1 below):

Market Highlights:

- 1 out of 3 robberies nationwide have involved the theft of a cell phone
- 1.8B handsets shipped per year worldwide
- 78M lost/stolen new handsets worldwide per year
- Enterprise market:
  - 4.3% of all employee smart phones are lost/stolen per year
  - 6.5% of 13.2M smart phones expected to be lost/stolen in 2013 will be recovered
  - 57% of lost/stolen smart phones were not security protected
  - 60% of lost/stolen smart phones are believed to contain sensitive and confidential information

- Crimes involving smart phones will exceed 3M per year in North America by 2014
- Lost and stolen smart phones will increase commensurate with smart phone growth
- Business smart phone losses will exceed consumer smart phone losses by 2016
- Unrecovered smart phones represent 13% of all replacement sales

Theft and Loss Model in North America

Robbery Data	2011	2012	2013	2014	2015	2016	2017	2018
Thefts								
North American Population - 2012	347,262,968	350,046,827	352,853,003	355,681,675	358,533,023	361,407,229	364,304,477	367,224,950
2009 data - per 100,000 people								
Robbery		137.6	137.6	137.6	137.6	137.6	137.6	137.6
Burglary/ Larceny/ Theft		2,805.5	2,805.5	2,805.5	2,805.5	2,805.5	2,805.5	2,805.5
Extrapolated to all of North America								
Robbery		481,664	485,526	489,418	493,341	497,296	501,283	505,302
Burglary/ Larceny/ Theft		9,820,564	9,899,291	9,978,649	10,058,644	10,139,280	10,220,562	10,302,496
Total Theft		**10,302,228**	**10,384,817**	**10,468,067**	**10,551,985**	**10,636,576**	**10,721,845**	**10,807,798**
Estimate - % Robberies involving cellphone		40%	50%	55%	55%	55%	55%	55%
Estimate - % Burglaries, Larcenies, Theft involving cellphone		20%	25%	28%	28%	28%	28%	28%
Lost and Stolen Handset Summary								
Estimated Total crimes involving cellphone		2,156,779	2,717,586	3,013,308	3,037,465	3,061,815	3,086,360	3,111,102
Estimated Smartphones Lost (not stolen)		8,398,981	10,445,805	11,856,859	13,312,792	14,337,418	15,133,262	15,949,377
Estmated Smartphones Recovered		(687,760)	(857,660)	(968,865)	(1,065,300)	(1,133,646)	(1,187,098)	(1,241,884)
		9,868,000	**12,305,731**	**13,901,303**	**15,284,957**	**16,265,587**	**17,052,524**	**17,818,595**
Theft Ratio		1.6%	1.6%	1.6%	1.4%	1.3%	1.3%	1.2%
Loss Ratio (Before Recovered)		6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%
Recovered		-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
		7.2%	7.2%	7.2%	7.1%	7.0%	6.8%	6.8%

Sources:
Population and Crime Stats: Government sources
Lost smart phone ratio: Ponemon Institute (white paper study sponsored by McAfee

Figure 1

1 "National Database Planned to Combat Cellphone Theft", New York Times, April 9, 2012

In April 2012, the FCC working with Congress, local police authorities, and wireless carriers determined the need to create a central registry to track stolen phones and prevent them from being used again on carrier networks[2].

Verizon Wireless, AT&T, Sprint and T-Mobile are working to put in place a program to disable phones reported as stolen, preventing them from being used on each other's networks[3]. This process of "blacklisting" the stolen device's IMEI prevents participating carriers for activating a stolen device on their networks.

More recently on November 1, 2012 and in support of FCC guidelines, AT&T and T-Mobile were the first U.S. carriers to share stolen phone information via a shared database[4]. By November 30, 2013, the major U.S. LTE carriers including those CDMA carriers that are deploying LTE networks (e.g., Verizon Wireless and Sprint) agreed to use a common database for stolen LTE smart phones, which will prevent any stolen LTE phone from being activated on another LTE network among these U.S. carriers. At present, these carriers have decided to use the GSMA IMEI Database for sharing the stolen serial numbers, or IMEI information.

Existing industry solutions consist of in-house, carrier-specific applications as well as and the use of the GSM Association's IMEI Database to blacklist stolen IMEIs from GSM/UMTS phones.

Our research shows that U.S. wireless carriers are opting for carrier-specific solutions for the short term. Long term, however, with the wide adoption of LTE, a shared, centralized EIR will be required to support the portability of devices from carrier to carrier. Today GSM/UMTS mobile phones can't be activated on CDMA networks and vice-versa based solely on technological limitations, but as LTE adoption spreads across the U.S. carriers, the need to distribute and receive blacklisted IMEIs among them, in real-time, at a national and global level, will become a necessity.

Based on industry requirements there is a need for a central, shared EIR to interface with and augment the existing GSMA IMEI DB, to fully extend to LTE networks and include the following:

- Ability to receive stolen IMEI information (with real-time distribution)
- Ability to report and retrieve stolen IMEIs to/from the carrier's own EIR, and update each carrier's black list (LTE and non-LTE lists)
- Ability to recall the reported stolen IMEIs after the stolen/lost phones have been recovered
- Ability to segment IMEI information based on network technology (LTE vs. non-LTE)
- Ability to segment IMEI information based on geographical area (US vs. global)
- Ability to broadcast IMEI information based on recipient's specification (e.g., any status change, only newly black listed IMEI or when a black listed IMEI becomes white listed)
- Ability to respond to queries from MNOs (notably MNO provisioning systems, during subscriber activation)
- Easy integration with existing systems
- Security and data integrity
- Database backup and recovery

2 Chairman Remarks on Stolen Cell Phones Initiative, FCC Commission Document, April 10, 2012
3 "Carriers Band to Fight Cellphone Theft", Wall Street Journal, April 9, 2012
4 "AT&T, T-Mobile First To Switch On Database To Track Stolen Cellphones", TmoNews, November 1, 2012

Figure 2 shows the benefits for using the NPAC for storing stolen IMEI information.

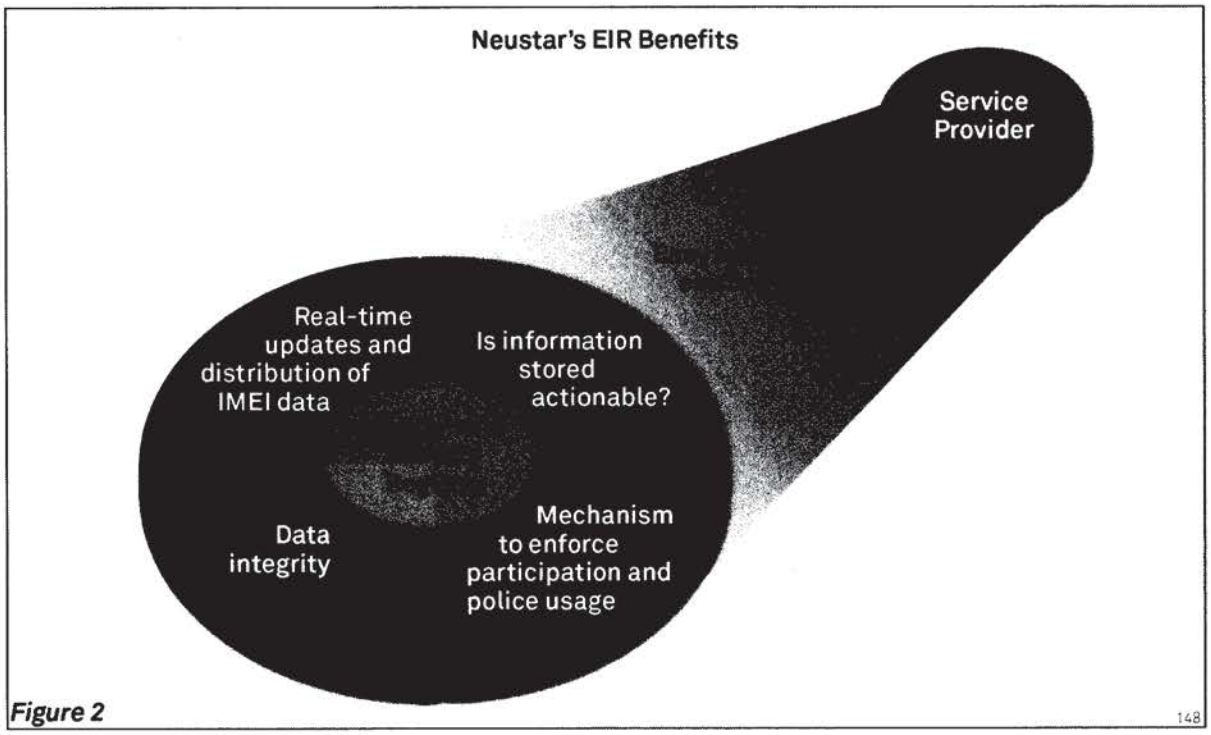

Figure 2

Neustar's EIR Solution

Neustar's approach will leverage the existing NPAC infrastructure to serve as the foundation for a new NPAC EIR service and provide a familiar and existing interface to the carriers.

The LNPA Working Group is currently finalizing specifications for NANC 372, which defines a new interface to the NPAC based on HTTPS and XML. Neustar proposes the extension of this interface to provide additional messages for provisioning, distribution, and querying of the EIR data. The new functionality will be part of the overall NPAC service, but the EIR data will reside separately from the NPAC data.

The EIR will support the following IMEI statuses: Black Listed, White Listed, Grey Listed, and Unknown Status. In addition the solution will provide validation of the IMEI data.

Solution Highlights:

- Leverage existing NPAC services
- Universally connected with carrier's EIRs and GSMA CEIR. Can be extended to CDMA EIRs
- XML interface makes it easy to interface with carriers existing back-end systems
- Proposed extension of XML interface to accommodate new functionality and analytics
- Real-time distribution of IMEI data among EIRs
- Data security and integrity
- Technology agnostic

We would like to note that this white paper discusses IMEI only for simplicity; however the solution can include the ESN and MEID used by the 3GPP2 systems.

Specifically, the NPAC EIR interface will provide the following messages as part of the XML interface:

- **Query_IMEI**— the client system provides an IMEI and the NPAC EIR Service returns the current status of the IMEI.
- **BlackList_IMEI**— the client system provides an IMEI and the NPAC EIR Service stores or updates the IMEI status to "Black Listed".
- **GreyList_IMEI** — the client system provides an IMEI and the NPAC EIR Service stores or updates the IMEI status to "Grey Listed".
- **Clear_IMEI**— the client system provides an IMEI and the NPAC EIR Service changes the IMEI status to "White Listed".
- **Download_IMEI**— the NPAC broadcasts a change in status for a particular IMEI whenever its status has changed.

Because the NPAC is regional in nature, but the NPAC EIR is not, the provisioning portion of the interface will be accessible via a connection to any NPAC region. For the broadcast portion of the interface, the Provider will indicate which LSMS region should receive the EIR downloads.

Alternatively, Neustar can offer a new instance of the interface that is not tied to any region, and is intended solely for the purpose of the EIR data. Providers can then treat this new instance of the interface as a separate region and send all EIR related requests there.

In addition to the real-time interface, the Neustar solution will also provide an FTP service that integrates with the GSMA CEIR service. The NPAC EIR service will act as a surrogate to the GSMA CEIR system, providing EIR data to the GSMA, and pulling down the CEIR data from the GSMA. Figure 3 shows Neustar's EIR architecture and its interface to the GSMA.

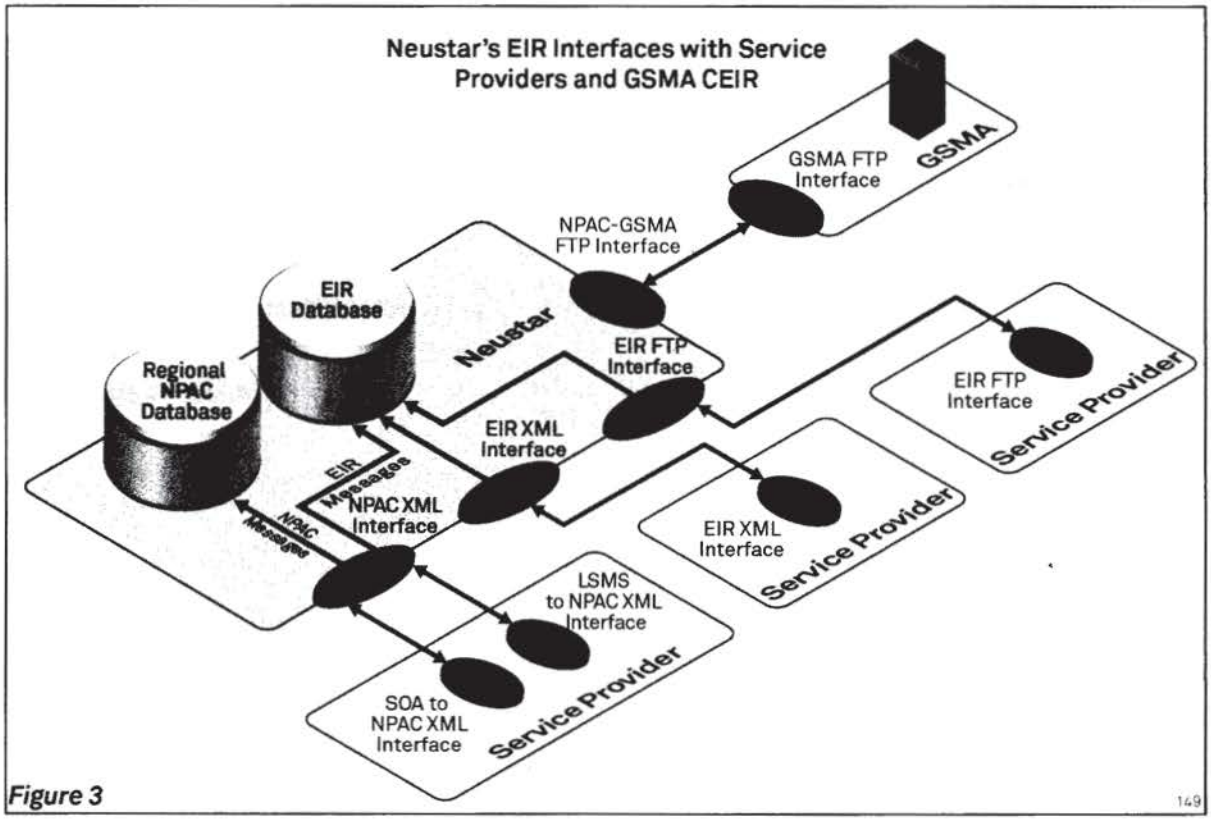

Figure 3

With this complete set of features, Neustar can accommodate any service model that customers may desire. Providers can transfer and download files to and from the Neustar service just as they do with the GSMA CEIR today. Or they can take advantage of the real-time messaging, implementing either a local EIR fed by the NPAC EIR service, or querying the NPAC EIR as needed.

The NPAC EIR service offers several benefits to Providers. First, it offers real-time access to EIR information. Second, it is based on a system architecture that is well established in the Provider's operational infrastructure. All of the communications, security and protocol support that support the NPAC will be leveraged for this new service, making it easy for Providers to integrate the NPAC EIR data with their existing systems if they so choose. Lastly, it comes with the backing of Neustar Customer Support, providing guidance, monitoring and security oversight. All of this is provided in a package that is fully compatible with the current GSMA offering, allowing Providers to take advantage of the features only when they are ready.

Future Considerations

There are several additional features that Neustar could offer to extend the value of the service.

1. The NPAC's EIR will have the capacity to track additional data associated with the IMEI, such as the TN, IMSI, SPID and date/time that White/Grey/Black Listed the device, or the technologies supported by the device. This could help Providers make smarter decisions about how to use the data. Providers can also filter the information they choose to receive based on technology designation (e.g., LTE and non-LTE capable devices) and/or geographical area (e.g., US or global).
2. The NPAC EIR could store a PIN with the IMEI at the time of Black/Grey Listing. This could facilitate the orderly removal of the IMEI from the Black/Grey List if a device recorded as stolen or lost is recovered.
3. When applicable, the NPAC EIR could interface with other CDMA regional or national EIRs to exchange EIR data on stolen devices.
4. The NPAC EIR could be made available to entities other than current NPAC customers. The proposed system leverages the NPAC to make it easy for current NPAC customers to access the new functionality. However, because the NPAC EIR itself is separate from the NPAC, Neustar could offer a separate interface that only presents the EIR specific messages, and bypasses the NPAC entirely. This way, entities such as retailers, manufacturers, insurers, and international Service Providers could enjoy the benefits of the system as well.

Benefits to the Industry

Leveraging existing NPAC services Neustar's EIR solution allows Service Providers to use existing technology and easily share stolen device information in real time, in a highly secure and universally interconnected environment.

The solution accommodates existing 2G/3G needs as well as LTE, allowing Service Providers and other approved users of EIR data to upload and query a central database. Service Providers have the potential to add functionality, new fields, and new business rules that the entire EIR eco-system can leverage in real-time.

Abbreviations Used in This Document

Acronym	Definition
3G	Third Generation
3GPP2	Third Generation Partnership Project Two
CEIR	Central Equipment Identity Registry
EIR	Equipment Identity Registry
FTP	File Transfer Protocol
GSMA	The GSM Association
HTTPS	Hypertext Transfer Protocol Secure
IMSI	International Mobile Subscriber Identity
LRN	Local Routing Number
LTE	Long Term Evolution
M2M	Machine to Machine
MNO	Mobile Network Operator
NP	Number Portability
PIN	Personal Identification Number
SPID	Service Provider ID
TN	Telephone Number
XML	Extensible Markup Language

M2M Number Administration, Interoperability, and Service Enablement

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Introduction and Market Overview

Solution Highlights:

- M2M devices will strain current TN supply and rely more heavily upon non-geographic area codes and 5YY numbers that are not interoperable
- M2M solutions are delivered in silo'd environments and fail to interoperate with a broader community of users
- NPAC can use URI fields to enable interoperability for both 5YY TNs and geographic TNs

Recent advances in wireless communications, embedded systems, and IP networking are spurring the growth of Machine-to-Machine (M2M) communications and services. M2M solutions are envisioned to connect billions of existing and new devices, ranging from high-end smart mobile devices to low-cost resource constrained wireless sensors. According to some estimates, there will be nearly 500MIL connected devices in the US, by year 2020. M2M technology can be beneficially applied to a broad range of use cases for smart grids, telematics, eHealth/mHealth, fleet management, industry control, home automation, and environmental monitoring.

Most M2M devices today are addressed using telephone numbers (TNs). However, there are challenges with the use of TN-based identfiers and addresses for these devices. Today they use either geographic TNs or TNs in the 5YY range. 5YY numbers have a downside in that they are not routable between networks They were never integrated into the PSTN and therefore are really just a private numbering space. At least some applications will require interoperability.

Regulators are getting concerned that demand for TNs for M2M may deplete their existing geographic area codes, causing new area codes to be added, and even exhaust of the entire NANP, which would require an expansion beyond 10 digits for NANP TNs.

As M2M cellular connects continue to rise, so does the fear that an unprecedented increase in telephone number demand will strain the current supply of NPAs. To better understand the M2M demand for telephone numbers, Neustar has developed forecasting models that predict TN exhaust by adding M2M TN demand on top of NRUF TN forecasts. The models developed forecast TN exhaust from a national level down to specific area codes seeking relief in the next five years as forecasted by NRUF (the most granular level of TN exhaust data available). The key driver for these models centers on a U.S. based, cellular M2M devices, all of which require a Telephone Number.

The national forecasting model builds upon the NRUF model by applying the annual demand of M2M devices against the long term NPA supply. Currently, NRUF estimates NPA usage with a straight line demand of approximately five NPAs per year. To be consistent, the M2M device usage was also calculated to a NPA unit by dividing the total incremental annual M2M demand by eight million, or the number of potential TNs in each area code. This resulted in the number of additional area codes that would be consumed by M2M. Together, the annual M2M device demand and NRUF forecast resulted in the existing NRUF forecast of TN exhaust by 2042 to run out 12 years earlier, or more than 40%, with forecasts of TN exhaust now pegged to 2030.

The area code exhaust model focuses on individual area codes already identified by the NRUF forecast to require relief within the next five years. The M2M demand is applied within each area code to highlight its impact. To properly apply M2M TN requests within each area code, the total U.S. M2M demand was normalized down to a common denominator based on the resident population of the U.S. For each year, the number of M2M devices was divided by the U.S. population to calculate an average M2M device per individual. This average M2M device per individual was then applied to each area code by multiplying it against its resident population. The aggregated M2M demand affects individual area codes by pulling in the year in which relief is required, years ahead of its original

forecast. The effects are dramatic from a resource planning perspective.

Currently based on NRUF exhaust tables, 75% of carrier relief expenditures would be required in 2015-2017. With the additional M2M demand, however, these same area codes will now require over 95% of the expense to be carried in 2013-2014 with 80% of the costs now needed in 2013. This disruptive funding shift will rattle many carriers' short term budgets and cause unplanned allocation of funds from other strategic programs. It should only be presumed that all remaining area codes would experience a similar shift in cost expenditures due to M2M TN growth, pulling into the near future unanticipated expenditures.

It should be noted that M2M demand is not leveled out across all areas codes, but rather tend to quickly amass in a small geographical area with a magnified affect on TN demand. This uncertainty applies a random probability to TNs usage and hampers the ability to accurately forecast exhaust.

The industry is in a difficult positon and it needs to continue to use TNs for some time, because any alternative identifier/address will be years away from having an impact, while not exhausting important existing resources.

Another problem with the current M2M solutions is that they are delivered in "silos" in an "over-the-top" (OTT) manner. While the network still provides connectivity services, most of the other services and application layer functionality is delivered by an M2M Service Delivery Platform (SDP) hosted by the application Service Provider. In this model, the set of devices and their users are pre-defined by the application and the interoperability between them is typically established through an "app" on the users' smartphone. As an example, in a home energy control application, the residents from the home download the "energy control app" on their smartphones which allows them access to the device for monitoring and control purposes. If the home owner needs to have the appliance manufacturer access the device "on demand" to diagnose a particular problem with the appliance, it is difficult to enable such access within the current M2M application framework because the application essentially behaves in a "closed" manner. Interoperability and access is limited to the users of the app.

Lack of openness and interoperability will prevent the promise of M2M services from being fully realized; an undesirable situation that the industry needs to address. Figure 1 shows the OTT M2M service delivery concept that is described above.

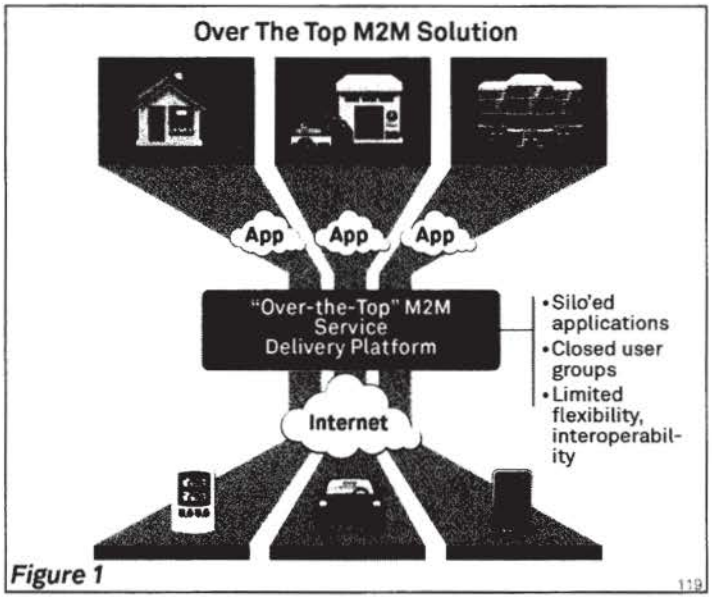


Figure 1

The industry needs to address the following issues in the near future:

- Administering TNs associated with M2M in a way that conserves this important industry resource
- Enabling interoperability for 5YY TNs
- Enabling interoperability between users across any network and M2M devices for all TNs
- Enabling the development of M2M applications that are open and flexible across a broad set of user communities

The NPAC can be the enabling platform for providing both administration and interoperability of M2M devices, applications, and users related to TNs.

Neustar's Solution

The industry should take advantage of the NPAC's inventory administration capabilities, thousand block pooling, to also administer M2M TNs. The NPAC can track the assignments and ensure that the resources are being used efficiently. A new M2MURI field should be added to the NPAC and used to enable interoperability for both 5YY TNs and geographic TNs. The existing URI fields can be used for IP interoperability and SMS message routing to enable message based communication between users and devices.

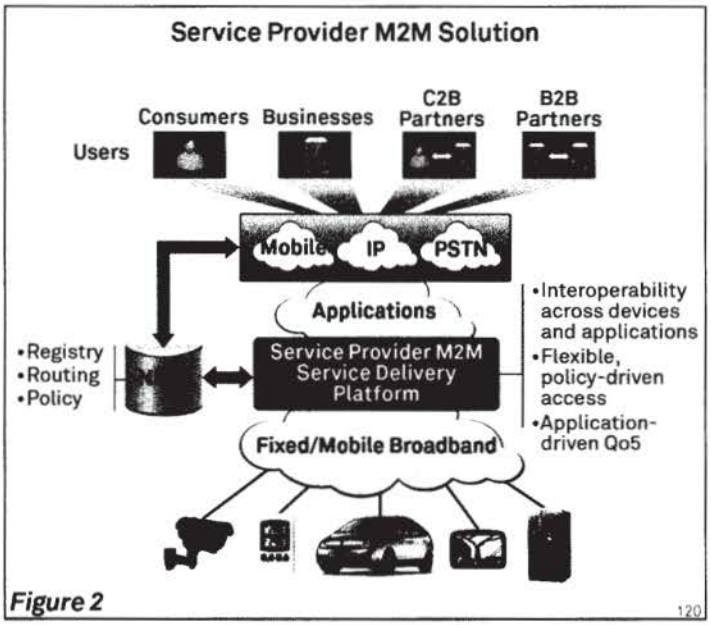


Figure 2

The NPAC can also become the enabler for a more flexible M2M Service Delivery Platform for Service Providers that can support a broader set of open applications than what is currently possible with the OTT Platforms. This more flexible Service Provider enabled solution is shown in Figure 2.

In this architecture, applications can be developed to provide more flexible access to users of different communities based on rules and policies defined by the "owner" of the application. Using the previous example of home energy control, the home owner can set rules for allowing access to the appliance manufacturer or servicing agent (shown as a "consumer-to-business (C2B) partner") to remotely diagnose the home appliance. The access can be enabled via mobile, IP, or PSTN networks from any device, but subject to proper authentication by the M2M SDP.

The NPAC can also enable the concept of telephone number "NAT-ing". This would enable multiple M2M services to be deployed by multiple Service Delivery Platform's using the single public telephone number as the key to all of the M2M services. This enables a plethora of M2M services to be delivered while preserving telephone numbers.

By adopting an M2M SDP that enables a wider set of interoperability between users and M2M

devices, Service Providers will be in a position to attract the application developer community with a more powerful set of APIs. This will unleash a large number of new applications that can drive faster adoption of M2M services, thereby generating increased revenue streams for Service Providers.

Benefits to the Industry

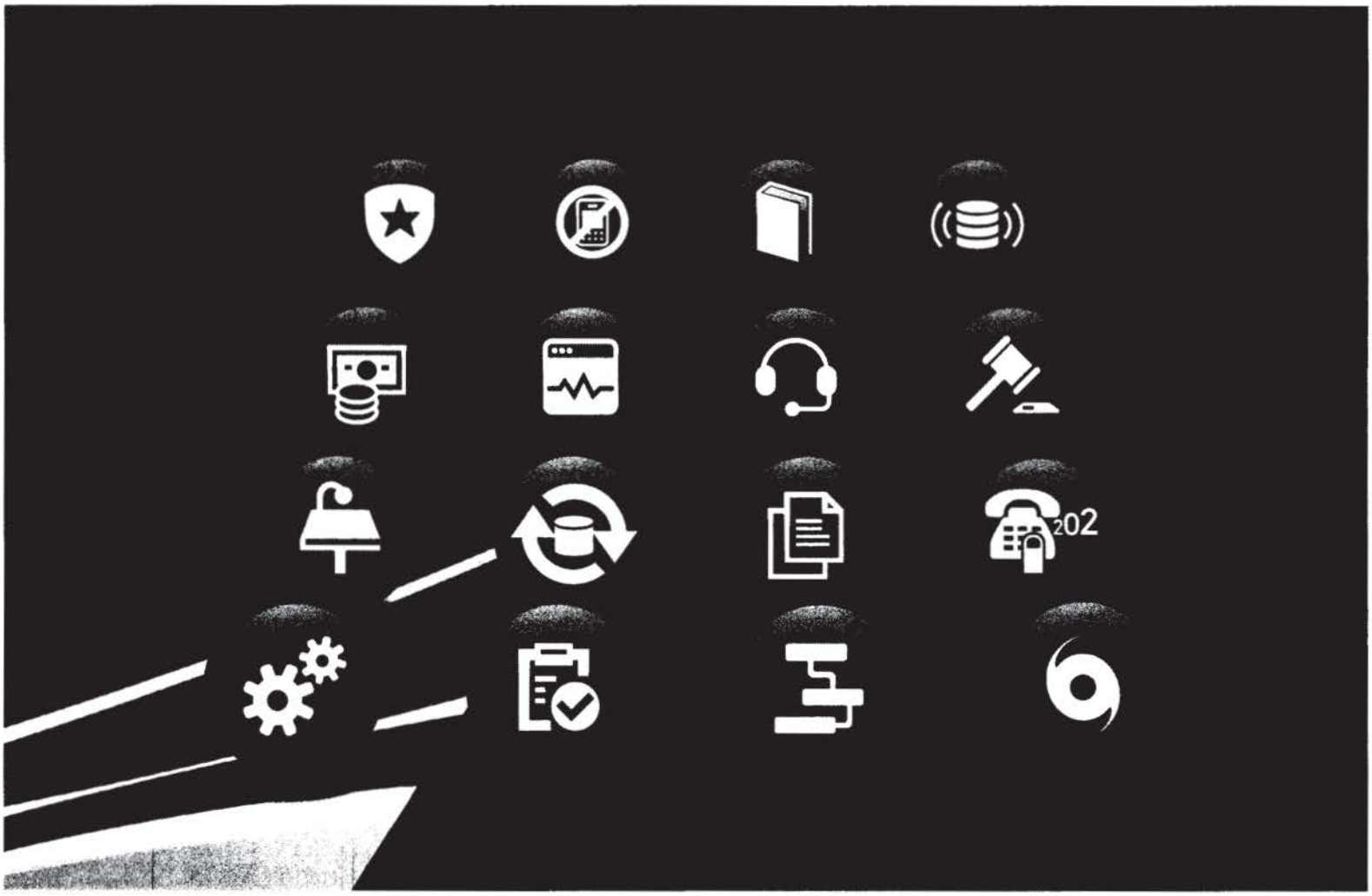
M2M is a significant opportunity for communications Service Providers to generate new revenue. The use of TNs is a requirement for many M2M applications and for connected devices because the current infrastructure requires it. However excessive demand for TNs for M2M may create regulatory issues. In addition the need for interoperability will require an efficient and effective solution. To take advantage of these opportunities the industry needs to proactively address issues regarding resource exhaust and interoperability so it can continue to provide these innovative solutions uninterrupted. The NPAC is the right platform for enabling any future capabilities for TNs. The upgrade to a web services interface will make it much easier to manage the enabling IP capabilities.

M2M service enablement is a lucrative growth area for Service Providers. However, the market currently is highly fragmented by OTT application providers. By leveraging their network assets and adopting a service delivery platform that enables broader interoperability and access to a wide spectrum of users, Service Providers can unleash the full potential of the M2M market. By virtue of its global registry and routing capabilities, the NPAC can readily enable a new breed of M2M services for the industry's benefit.

Abbreviations Used in This Document

Acronym	Definition
C2B	Consumer to Business
M2M	Machine to Machine
NAT	Network Address Translation
NRUF	Numbering Resource Utilization/Forecast
PSTN	Public Switched Telephone Network
SMS	Short Message Service
URI	Universal Resource Identifier

SMS Message Routing - Landline Numbers



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Introduction and Market Overview

Over the last few years IP technology has enabled Short Message Service (SMS) capability to be extended beyond mobile devices. Because of these changes many types of new SMS providers have entered the marketplace. These new entrants use telephone numbers obtained from Landline service providers. This has created a problem for SMS messages that are destined to these Landline numbers because Wireless operators do not recognize these numbers as being SMS capable. By default, Wireless operators consider Landline numbers not to be capable of SMS.

Today, the Messaging ecosystem uses mutliple sources of data to enable SMS routing, but the main source of data is the Number Portability Administration Center (NPAC). By default, all telephone numbers that have the SV Type field populated with Wireless are automatically included into the Messaging ecosystem as SMS capable.To date, there has not been a consistent, transparent method of indicating a Landline telephone number's SMS capabilty as exists for Wireless numbers. The current method of whitelisting Landline numbers (Figure 1 below) is disjointed, largely proprietary and administered by mutiple organizations within the industry.

The industry needs to address the following issues with respect to indicating the SMS capability of Landline numbers:

1. Indicate the SMS capability of Landline numbers in a consistent, centralized manner using a non-proprietary database
2. Insure transparency exists and the entity responsible for SMS on each telephone number can be identified
3. Provide tools to users to be able to access the centralized database
4. Protect the telephone number assets of carriers
5. Insure that any solution is aligned with number portability

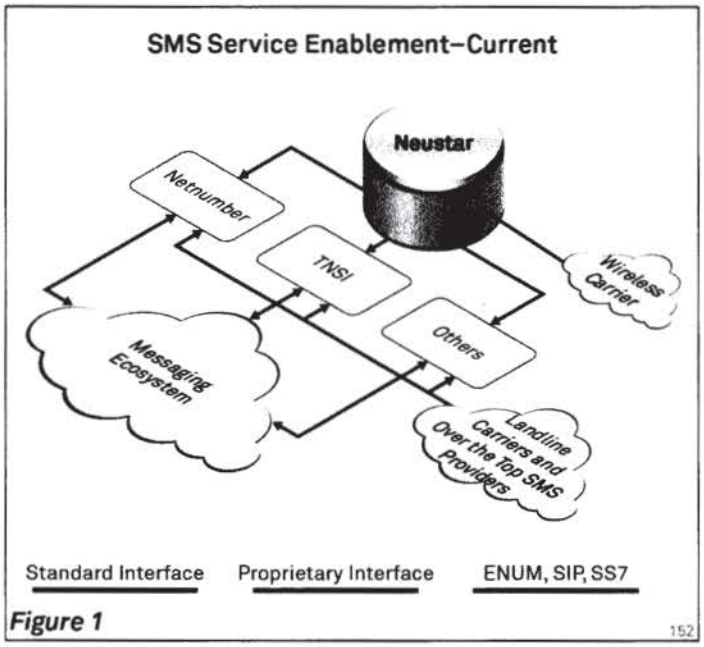

Figure 1

The NPAC can be an enabling platform for indicating and identifying SMS capable Landline telephone numbers. The NPAC can facilitate SMS service to those numbers in a manner that solves today's messaging ecosystem problems.

Neustar's Solution

NPAC's existing TN inventory administration capabilities along with the SMSURI field and can be used to also administer Landline SMS capable telephone numbers in the same database that manages Wireless telephone numbers.

The NPAC can be the central location to identify numbers that are SMS capable and distribute this data to the messaging ecosystem. The information populated in the SMSURI field will be consumed by

relevant Service Providers and mapped to current route information using various types of SPIDs. No changes are required to how current SMS routes. This will enable easy and open access to determine the entity actually responsible for the SMS. The information can be obtained via tools such as PortPS which is available at no cost to NPAC users.

Neustar's proposal (depicted in Figure 2) does not require changes to how SMS is routed today, this only affects how the telephone number used to route SMS is made SMS capable (aka whitelisted). The information stored in the SMSURI field is flexible and has no specific limitations as to syntax. By populating the SMSURI field the SMS Service Providers (Carriers and Over The Top) agree to be in compliance with Section 4.1 of the CTIA SMS Interoperability Guidelines Version 3.2 (http://www.ctia.org/business_resources/index.cfm/AID/12056.)

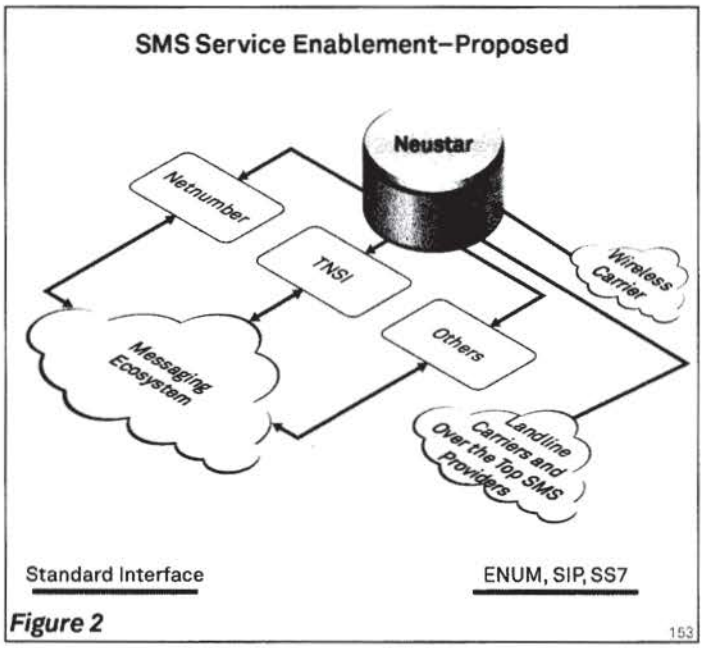

Figure 2

The following use cases are described below:

- Landline operator directly offering the SMS service to their subscriber base
- Reseller or Over-The-Top provider offering SMS services to their subscriber base

Landline Operator Directly Offering SMS Service

In this use case, the Landline operator (CLEC, ILEC, or Cable) will offer an SMS service directly to their subscriber base. The SMS service may be operated by a designated 3rd party, but the service is using the Landline operator's telephone numbers.

The following parameters are needed:

- Landline operator has a SPID value of 1234 that is associated with their numbers in the NPAC.
- Landline operator (or their designated 3rd party that is providing SMSC services) is using Inter-Carrier Vendor, ICV-A.
- The messaging ecosystem has route tables built that map SPID 1234 to ICV-A. ICV-A maps SPID 1234 that contains an SMPP bind to Landline operator SMSC (or their 3rd party SMSC)

The following steps occur when the Landline operator wishes to SMS enable their subscriber's telephone number.

1. Landline operator updates the SMSURI field in the NPAC with a value of sms.landlineoperator.com (note: this field is flexible and the syntax is flexible to what the industry needs)
2. Changes to the SMSURI field are distributed by the NPAC to all NPAC users, including the messaging ecosystem databases

3. The telephone number is now SMS capable and SMS will route to the Landline operator' SMSC (or 3rd party SMSC) via ICV-A

Reseller or Over-The-Top Provider Offering SMS Service

In this use case, the Landline operator (CLEC, ILEC, or Cable) will allow non-carriers to use their telephone numbers in order to offer SMS services.

The following are the parameters of the use case for OTTCo, the entity offering the SMS service and Landline operator, the entity that leased the telephone number to OTTCo:

- Landline operator has a SPID value of 6789 that is associated with their numbers in the NPAC
- OTTCo has a SPID of E123 inside the messaging ecosystem
- OTTCo is using Inter-Carrier Vendor, ICV-A
- The Messaging ecosystem has route tables built that map SPID E123 to ICV-A. ICV-A maps SPID E123 that contains an SMPP bind to OTTCo SMSC

The following steps occur when OTTCo wishes to SMS enable their subscriber's telephone number:

1. Landline operator updates the SMSURI field in the NPAC with a value of sms.ottco.com (note: this field is flexible and the syntax is flexible to what the industry needs)
2. Changes to the SMSURI field are distributed by the NPAC to all NPAC users, including the messaging ecosystem databases
3. The telephone number is now SMS capable and SMS will route to OTTCo SMSC via ICV-A

Benefits to the Industry

Messaging (SMS and MMS) is a significant revenue source for the Industry. It is important to have Landline numbers SMS-enabled in a similar fashion to how Wireless numbers are SMS capable. This solution will make transparent all numbers that are SMS capable as well as the entity offering the SMS service behind the number. This transparency will enable the Industry to identify SPAM origination and make it easier to stop.

The SMSURI field is already in the NPAC and is being used today. There is no additional cost to the industry for using the NPAC to SMS-enable Landline telephone numbers. Neustar will work closely with Landline carriers and Over the Top providers to minimize any changes to existing white list processes. Lastly, this solution requires no changes to current processes used by Wireless carriers.

Abbreviations Used in This Document

Acronym	Definition
CTIA	Cellular Telecommunications Industry Association
ILEC	Incumbent Local Exchange Carrier
NPAC	Number Portability Administration Center
SV	Subscription Version
SMS	Short Message Service
TN	Telephone Number

Enhancing NPAC's Role in Dynamic Addressing and Routing

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Introduction and Market Overview

The ongoing introduction of the Voice Over LTE (VoLTE) IP calling technology in mobile networks promises to enhance the mobile customer experience through the use of HD voice and reduce operating costs by carrying all voice traffic over more efficient, digital networks. Neustar has identified the opportunity to make handset roaming even more efficient under the LTE paradigm by making information visible to originating carriers which can then route the calls directly to the appropriate LTE or 3G network. This enables optimal call routing and cost savings for the industry.

Highlights:

- Optimal call routing
- Efficient use of network resources
- Improve voice quality over LTE
- Leverage the NPAC to update and disseminate handset network registration information

As consumers migrate to bandwidth intensive smart phones and the myriad of available data driven applications, mobile operators have similarly turned to an end-to-end IP based solution, LTE, to more efficiently deliver broadband data and help drive down their operational costs. LTE is an all IP architecture wherein voice, data, video services, and other rich media communications services based upon the 3GPP IP Multimedia Subsystem (IMS) standard. The IMS based voice solution in LTE networks is often referred to as VoLTE, or Voice Over LTE. Figure 1 shows a high level architecture of VoLTE:

Voice Over LTE Architecture

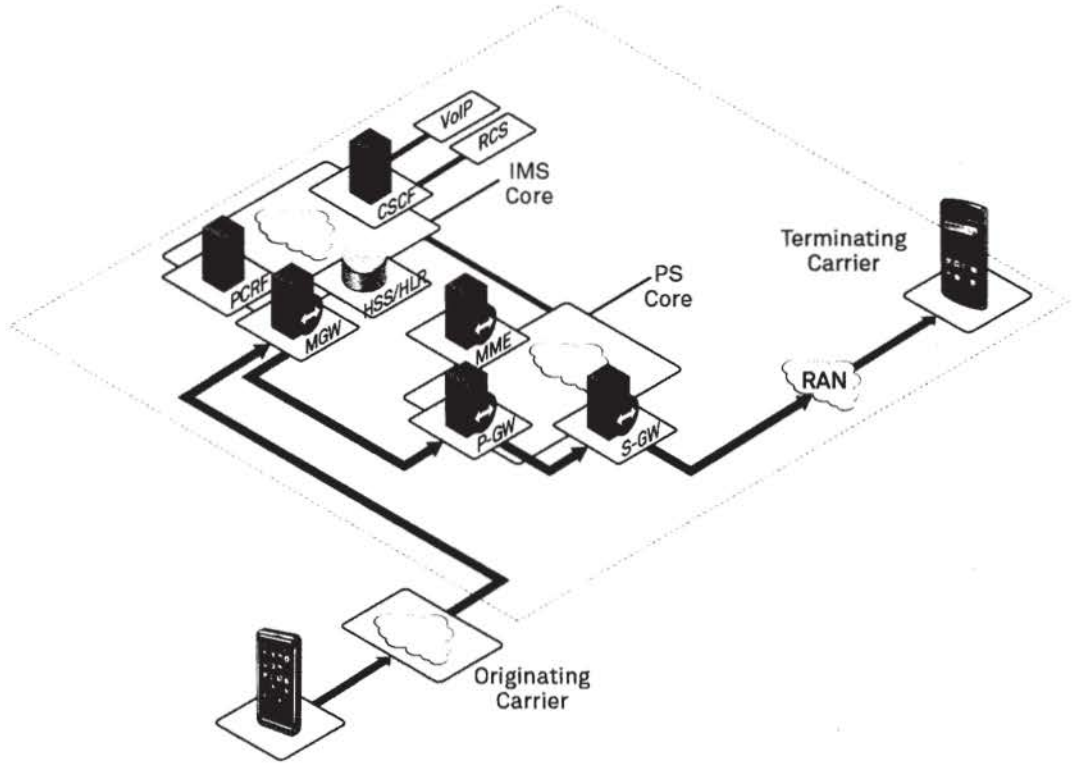

Figure 1

115

The IMS Core consists of the following main elements: the Session Control Entity (CSCF) that holds call state and is responsible for routing of the call and supporting application services, the subscriber

database (HSS/HLR), the Policy Control Entity (PCRF) that holds the rules for call handling, and the Media Gateway (MGW) that converts the media and signaling between IP and circuit, and connects with external networks for inbound and outbound calls. The S-GW, P-GW and MME are entities in the packet domain that handle the connection of the handset to the LTE network including handovers and mobility management.

VoLTE handsets are addressed by TNs but when they register with the HSS/HLR, they are also assigned an IP address. Incoming calls from another network are routed to the MGW, which sends the call to the CSCF, which then routes it to the handset if the handset is registered in the VoLTE domain.

Currently, most carriers have not enabled VoLTE as their voice mechanism, rather relying upon legacy 2G or 3G technologies to carry voice traffic. The migration to VoLTE will enable the eventual decommissioning of legacy networks to dramatically reduce the cost of multiple network technologies as well as free up valuable spectrum for more spectral efficient LTE. The deployment of VoLTE will most likely be market based, thus creating scenarios where, VoLTE coverage will not be available in all regions of the carrier's network. When a VoLTE user roams out of their home VoLTE network into a non-VoLTE coverage area, their device will attach to the existing 3G network in that area instead. Once the handset registers with the MSC/VLR of the 3G network, the LTE HSS/HLR is updated with the new routing information. However, any external or competitive network will not be aware of the device's new network location, therefore these networks will continue to route the originating call to the MGW of the VoLTE domain. It is only through the updated HSS/HLR routing information that the CSCF knows about the new point of attachment of the user device and will re-route the call through another MGW connecting the 3G network. This roaming scenario along with the new call path is shown in Figure 2.

Normal Routing for VoLTE Devices Outside of VoLTE Coverage

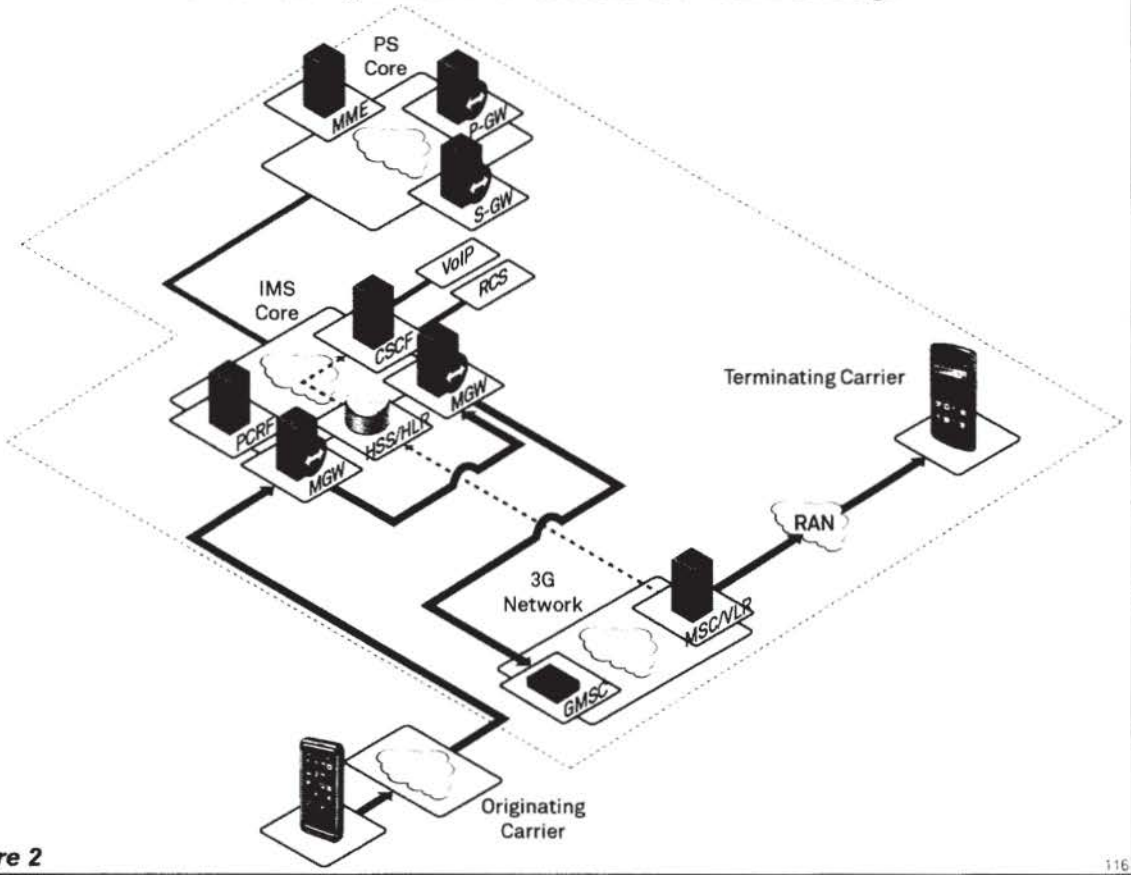

Figure 2

The current call path within a carrier's 3G and 4G VoLTE network makes inefficient use of network resources; in particular it uses two additional MGW ports that add infrastructure cost, which can be avoided by routing calls directly to the 3G network without traversing through the IMS network so it can terminate in the 3G network. In addition to the incremental cost of the MGW ports, the call quality could potentially degrade due to the added latency of the trombone effect and the back-to-back circuit-to-packet media conversions at the two MGWs. Poor voice quality can lead to abandoned calls and declining customer satisfaction.

Neustar's Dynamic Routing Solution

The inefficient routing of calls within a carrier's VoLTE and legacy circuit switch networks can be avoided if the updated routing information, as the handset roams between networks, can be made visible to the originating carrier who can then route the call directly to the 3G network's gateway MSC. As shown in Figure 3, the NPAC is the ideal vehicle to update and disseminate the handset's network registration information to all the carriers to enable optimal call routing.

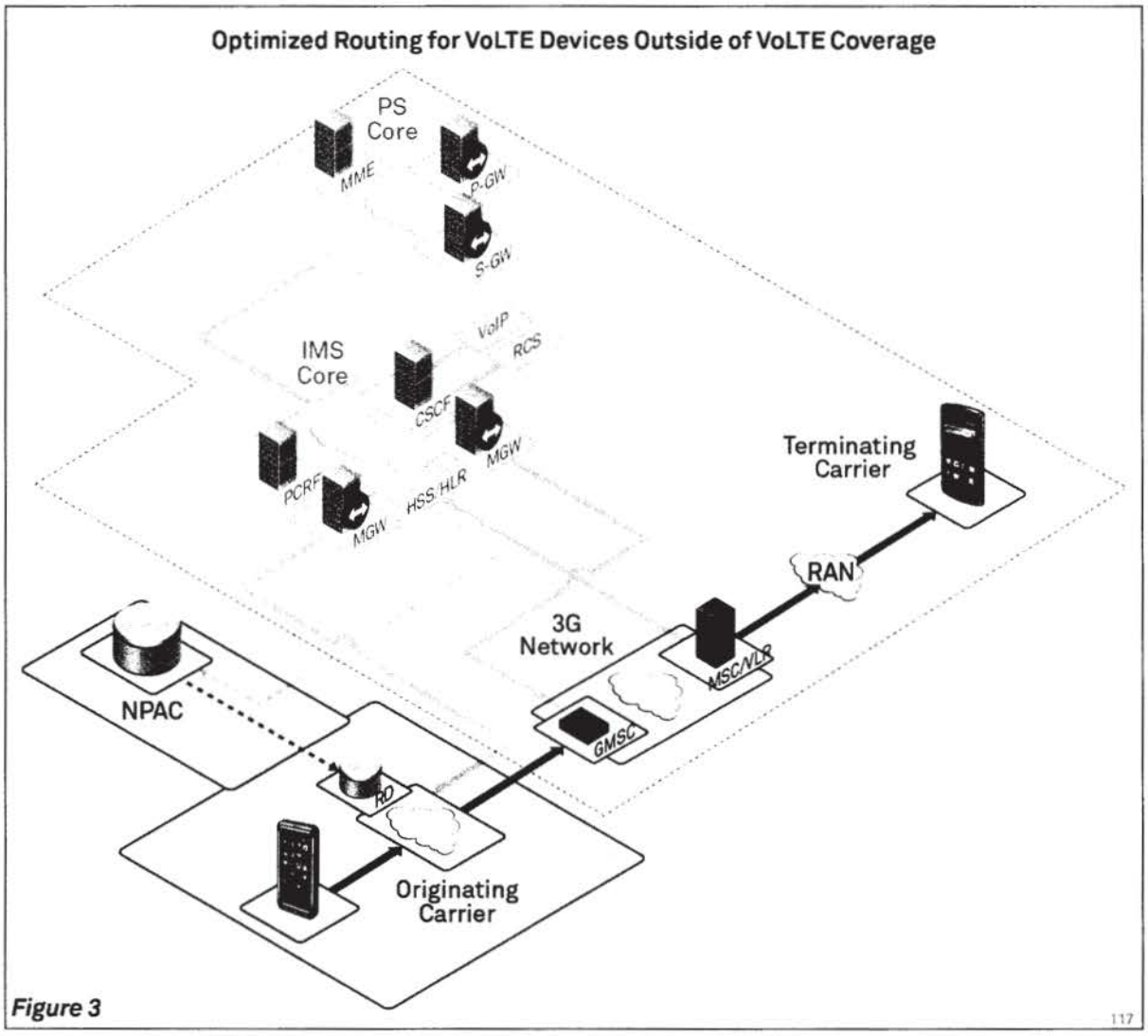

Figure 3

The proposed NPAC-based solution describes how the NPAC can be used in determining VoLTE and 3G coverage while subscriber is roaming:

The wireless Service Provider establishes an alternate LRN for LATA within the LTE coverage area, to signify the Gateway MSC of the 3G network.

When the user moves out of the LTE overage area into 3G network, the MSC/VLR updates the HSS/ HLR database with the new registration information.

A new NPAC module will subscribe to the registration state update in the HSS/HLR. Upon receipt of an update, this new module will update the NPAC/SMS for the affected TN with the new 3G LRN through either:

- A Modify transaction, when the TN already has an active, non Pseudo-LRN SV in the NPAC, or
- A Create/Activate transaction, when the TN is not in the NPAC within an Active Pooled Block, or has a Pseudo-LRN SV

The NPAC will distribute the updated LRN information to other carrier networks through the LSMS broadcast. Based on this new routing information, the originating carrier will route the call directly to the Gateway MSC of the 3G network as shown in the Figure 3, bypassing the LTE network and avoiding extra steps to route to LTE.

When the user moves back into the home LTE network, the HSS/HLR is updated with the new user registration. This updated information is again obtained by the NPAC and propagated into other carrier networks to revert the routing back to the normal case.

Benefits to the Industry

We have addressed the problem of optimal routing for calls to a VoLTE device when the user roams outside the VoLTE coverage area into a 3G network. The proposed solution based on new updates to the NPAC as triggered by the HSS/HLR registration updates, allows for optimal call routing when the user is attached to a 3G network.

With our proposed solution, the incremental cost to deploy additional MGW ports will be eliminated for non-LTE roaming situations. Notwithstanding, all carriers migrating to VoLTE will encounter these capital expenditures that can now be avoided with the NPAC solution.

Abbreviations Used in This Document

Acronym	Definition
3G	Third Generation
CSCF	Session Control Entity Function
HLR	Home Location Register
IMS	IP-Based Multimedia Subsystem
LATA	Local Access and Transport Area
LTE	Long Term Evolution
MME	Mobility Management Entity
NPAC/ SMS	Number Portability Administration Center/Service Management System
P-GW	Packet Gateway
S-GW	Serving Gateway
VoLTE	Voice Over LTE

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